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WASHINGTON, D. C. 20024

**G 9078**

SUBJECT: MSFC Lunar Mobility Task Team  
Meeting, September 3, 1969 -  
Case 320

DATE: September 29, 1969

FROM: J. C. Slaybaugh

ABSTRACT

A Lunar Mobility Task Team has recently been formed in the Advanced Projects Office of MSFC. Responsible for definition and development of various hardware items for lunar surface exploration, the group is currently studying an unmanned Lunar Exploration Vehicle (LEV), the LM modifications necessary to accommodate such a vehicle and a one-man short range Lunar Flying Unit (LFU). Several questions arise as to the desirability and practicality of an unmanned LEV mission to replace a manned lunar mission. In addition, the scale of LM modifications required to support such a mission may prove prohibitive. Additional effort toward development of an LFU would seem to be timely and useful.

The formation of the Lunar Mobility Task Team provides a focus for an important aspect of lunar exploration.

(NASA-CR-112559) MSFC LUNAR MOBILITY TASK  
TEAM MEETING, 3 SEPTEMBER 1969 (Bellcomm,  
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**BSC 00078**

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Meeting, September 5, 1969 -  
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**DATE:** September 29, 1969

**FROM:** J. C. Slaybaugh

MEMORANDUM FOR FILE

INTRODUCTION

A Lunar Mobility Task Team has recently been organized in the Advanced Projects Office of MSFC. Under the direction of Mr. Rodney D. Stewart, the group has as its primary function the definition and development of MSFC hardware to be used for lunar exploration. The group has responsibility for the following seven hardware items:

1. Dual-mode Lunar Roving Vehicle (DLRV)
2. Unmanned Lunar Exploration Vehicle (LEV)
3. Lunar Flying Unit (LFU)
4. Lunar Ground Effects Vehicle (GEV)
5. Lunar drill
6. Science package for LEV
7. LM modifications necessary to accommodate the above hardware

To the extent that efforts in these areas might overlap with similar programs at MSC (e.g. LFU, GEV, and LM modifications), Mr. Stewart indicated that concurrence has been reached with Mr. Andre Meyer of MSC as to the specific areas of responsibility for each center. MSC will retain its control over mission planning and operations, while MSFC will assume responsibility for hardware development of these items.

Attachment I outlines proposed development schedules for the hardware listed above. The MSFC program is designed to develop low cost, minimum impact hardware which will permit maximum advantage to be taken of the current Apollo capability in a lunar exploration program. With the exception of the lunar drill, all items are scheduled for flight readiness in the pre-Apollo 20 period. The optimism built into these schedules is open to question, but the LMTT feels that with immediate implementation the schedules can be met.

Current study by the Task Team is directed most heavily toward the LEV, the LM modifications necessary to fly the LEV, and the LFU. Meetings were held at MSFC on September 5, 1969, to discuss these items. The following remarks summarize the information presented at those meetings.

#### LUNAR EXPLORATION VEHICLE (LEV)

The Lunar Exploration Vehicle (LEV) under study by MSFC is a fully automated, unmanned vehicle with real-time control from Earth. It will be required to operate for a minimum of fourteen days and survive through one lunar night. The vehicle is planned to provide a capability somewhere between that of the DLRV and a roving Surveyor. In contrast to the DLRV and the Lunar Roving Vehicle (LRV), however, the LEV will be designed for unmanned use only, and performance will not be compromised to accommodate manned operation.

Based on LRV and DLRV studies, Grumman Aircraft Engineering Company (GAEC) has recommended a 6x6 wheeled vehicle (six wheels, six motors) capable of automatic deployment. Maximum vehicle weight, based on LM bay hard point limitations, is 1000 pounds (including a 200 pound scientific package). Unlike manned vehicles, for which the time-limited life support system dictates a high speed to cover a given distance, the LEV will operate at low speeds using a mechanical obstacle avoidance system. Upon sensing an obstacle, the vehicle will stop until avoidance action is commanded from Earth.

Two mission options have been described for the LEV: an unmanned LM landing of two LEV's with a simultaneous manned orbital CSM mission, and a manned landing carrying one LEV to be deployed and left on the lunar surface. Questions arise regarding both missions, however. An unmanned LM landing will require significant LM modifications. In addition, it is not clear that replacement of a manned lunar landing by an unmanned mission is a desirable trade. The status of the suggested manned CSM-only mission will undoubtedly have a major impact on this LEV mission

The manned landing with an LEV presents further problems. It is doubtful that a manned landing will have the capability of carrying a 1000 pound payload. Even assuming that such a capability exists, the desirability of an LEV over an LRV or an ALSEP package is questionable. Since only one such payload could be carried per landing,\* it is doubtful that such a trade would be made. Close attention should be given to these problems before a firm commitment is made to LEV development for Apollo Lunar Exploration.

The program outlined by the LMTT includes a phase B study effort to begin as early as October 1, 1969. Preliminary design would be completed by March 15, 1970, and flight hardware would be scheduled for delivery by mid-1972. This would permit an LEV mission on Apollo 20. The accelerated schedule (compared to the LRV program) would be met by a reduction in reliability and quality testing required for the manned vehicle.

Two problem areas have been identified by GAEC in a preliminary study of the LEV. Both relate to the goal of producing a simple vehicle for low cost. The first is the question of providing sufficient heat for night survivability. The high cost of radioactive thermoelectric generators (RTG's) makes their use impractical, and current plans are to use nuclear strip heaters for thermal control.

The second problem cited by GAEC involves the method of control and steering. Simultaneous operation of the vehicle television and locomotion systems creates a large power drain. Elimination of full-time T.V. would reduce vehicle weight and cost considerably. The resulting intermittent locomotion and T.V. does not, however, provide an operationally satisfactory vehicle.

It is clear that several questions must still be answered before the LEV could be developed. In addition to the hardware areas discussed above, the basic decision as to the usefulness of an unmanned vehicle to be flown at the expense of a manned lunar landing must be considered.

#### LM LEV MODIFICATIONS

In keeping with the general Task Team objective of minimum changes in the existing Apollo hardware, the sizing of all new lunar exploration hardware will be determined by the current LM capabilities. A preliminary study to define these capabilities is already under way at GAEC. Attachment II is a "deletion list" resulting from that study.

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\*Petrone, R. A., "Apollo Lunar Exploration, Program Implementation Decisions and Open Items, OMSF Management Council Meeting, September 9-10, 1969." Telegraphic Message M-C MA, p. 2, Item 3, September 11, 1969.

Based on LM 6, the information provided by Grumman shows that for an unmanned lunar landing a total of 7722 pounds can be removed from the current Lunar Module. Of this total, 5660 pounds can be saved by offloading various consumables (i.e. 4976 lbs of ascent stage propellants, 352 lbs of non- $\Delta V$  propellants, and 382 lbs of other liquids and gases). The additional weight savings would involve equipment modification and removal. Since only 990 pounds of equipment (exclusive of payload) is estimated necessary to modify the LM for unmanned operation, it appears that a 4000 pound payload capability would be provided by offloading consumables. The effect that this offloading would have on c.g. position was not discussed.

As mentioned previously, the modifications required to perform an unmanned landing may be significant. The problems of sequencing without a pilot, signal reacquisition after an antenna loss of lock, and rough terrain landing, may prove to be out of the realm of "minor impact" items planned by the LMTT. Such modifications will have to be carefully studied on the basis of cost and scheduling impact on the overall Apollo program. In addition, further study will have to be done in the areas of propellant offloading, LEV mounting on the descent stage (including clearance of Quads I and III), and the impact of modifying an existing LM vs using a flight vehicle already assembled.

The LM modification program outlined by the LMTT will be a phase B study effort. MSFC hopes to be able to award a contract by October 1, 1969, with final review due by March 15, 1970. The program will aim at producing two vehicles; the first, a flight ready article and the second, an assembled backup vehicle.

#### LUNAR FLYING UNIT (LFU)

MSFC interest in lunar flying vehicles is directed toward a small one-man vehicle designed for emergency astronaut return to the LM. Although the Lunar Flying Unit (LFU) would not be used for primary transportation, the engineering experience gained from its development and use could be the basis for a larger primary transportation vehicle. Based on its past experience with flying vehicles, Bell Aerosystems Company (BAC) was asked to present its findings on the feasibility of such a vehicle at the LMMT meeting.

BAC discussed three basic types of vehicle with which it has had experience: 1) the rocket belt, 2) the POGO vehicle, and 3) the One Man Lunar Flying Vehicle (OMLFV).

Of the three, the POGO vehicle was closest to the type of vehicle of interest to MSFC. Shown in Figure 1, the POGO is a 100 lb dry weight vehicle weighing 200 lbs fully loaded (without crew). Using either LM residual bipropellants or hydrogen peroxide fuel, the vehicle would be capable of one-way ranges up to 5 km. BAC estimates that flight unit could be delivered within 20 months of contract award. Since Bell has already performed design studies on this type of vehicle, the major development item involved is the qualification and testing of the engines.

The other two vehicles described by Bell were the OMLFV and the rocket belt. The OMLFV is a larger vehicle (370 lb payload in addition to the astronaut and one-way range up to 30 km) and would require considerably more development time and money. The rocket belt is a smaller vehicle with severely limited range capability.

Mr. Stewart indicated that he felt sufficient time and money had been spent in the area of lunar flyers to make a hardware decision appropriate. Since work has stopped in this area at MSC (Bell and NAR phase B OMLFV study has just been completed), he indicated that MSFC is willing to pursue the matter at this time.

#### CONCLUSIONS

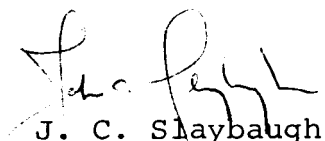
The formation of the Lunar Mobility Task Team at MSFC provides a focus for an important aspect of lunar exploration. It is not clear, however, that the group's immediate concern for an unmanned vehicle for flight in the Apollo 16-20 period is justified. Further study will have to be undertaken to determine whether or not such a vehicle would have sufficient merit to warrant replacement of a manned lunar landing. In addition, the LM modifications required to perform an unmanned Apollo landing and the small payload capability afforded on a manned mission raise serious doubts regarding the feasibility of flying the LEV.

The LFU, studied in several forms for quite some time, appears to be an important item for lunar exploration development. Assuming a continuing program of lunar exploration, a lunar flyer of some sort would be an obvious choice to supplement rover mobility. The engineering experience gained from the operation of an LFU in the lunar environment would thus provide useful data for future flyer development.




Other items for which the LMTT has responsibility (i.e. DIRV and GEV) deserve serious consideration for the post-Apollo 20 period. Hopefully, the establishment of the LMTT at MSFC will provide a center for additional studies in the lunar surface mobility area.

2032-JCS-mp

Attachments  
I and II  
Figure I

  
J. C. Slaybaugh

# ATTACHMENT I

MARSHALL SPACE FLIGHT CENTER PROGRAM DEVELOPMENT		LUNAR EXPLORATION HARDWARE					NAME: PD-AP		
							DATE: Sept. 5, 1969		
CALENDAR YEAR		69	70	71	72	73	74		
FISCAL YEAR		69	70	71	72	73	74		
LUNAR ROVING VEHICLE LRV		PHASE B							
									
		DEVELOPMENT		DEVELOPMENT		DELIVERY Δ Δ Δ Δ		FLIGHT Δ	
LUNAR EXPLORATION VEHICLE LEV		PHASE B							
									
		DEVELOPMENT		DEVELOPMENT		DEVELOPMENT		DEVELOPMENT	
SCIENCE PACKAGES		DEVELOPMENT							
		PROCUREMENT							

# ATTACHMENT I (Continued)

MARSHALL SPACE FLIGHT CENTER PROGRAM DEVELOPMENT		LUNAR EXPLORATION HARDWARE (Continued)					NAME: PD-AP DATE: Sept. 5, 1969	
CALENDAR YEAR	69	70	71	72	73	74		
FISCAL YEAR	69	70	71	72	73	74		
LUNAR MODULE MODIFICATIONS	ELM	DESIGN		LM-10				
		HARDWARE MODS						
		DESIGN		LM-15				
				HARDWARE MODS				
GROUND EFFECTS VEHICLE GEV		PHASE D		DEVELOPMENT				
LUNAR FLYING UNIT LFU	NSC STUDY							
	MSFC PHASE B				DEVELOPMENT			
LUNAR DRILL 100 FT.		PHASE B						
				PHASE C				
					DEVELOPMENT			

PRELIMINARY

# ATTACHMENT II

SUBSYSTEM/COMPONENT	REMOVED	( POUNDS)	ADDED	( POUNDS)
Structure	<ul style="list-style-type: none"> <li>o Ascent Engine Blast Deflector</li> <li>o Ascent Stage Propulsion Supports</li> <li>o RCS Supports (1/2)</li> </ul>	9 31 25	<ul style="list-style-type: none"> <li>o Payload Support Structure</li> </ul>	670
Guidance, Navigation and Control	<ul style="list-style-type: none"> <li>o Rate Gyro Assembly</li> <li>o Abort Guidance Section</li> <li>o Attitude Control Assembly (1)</li> <li>o Thrust Trans. Control Assembly (2)</li> <li>o Rendezvous Radar</li> <li>o Align. Optical Telescope (GFE)</li> </ul>	2 53 9 10 78 25	<ul style="list-style-type: none"> <li>o IM Optical Tracker System</li> <li>o IM Mission Programmer</li> </ul>	30 65
Crew Provisions	<ul style="list-style-type: none"> <li>o Crew Restraints &amp; Furnishings</li> <li>o Waste Management</li> </ul>	34 13		
Environmental Control	<ul style="list-style-type: none"> <li>o Atmosphere Revitalization Section</li> <li>o Ascent Stage Water &amp; GOX Tanks, Plumb'g</li> <li>o Descent Stage GOX Tank, Plumbing and Control Module</li> <li>o LiOH</li> </ul>	148 49 68 18		
Landing Gear (no change)				
Instrumentation	<ul style="list-style-type: none"> <li>o Transducers on deleted components</li> </ul>	~		
Electrical Power Supply	<ul style="list-style-type: none"> <li>o Ascent Stage Batteries (2) &amp; ECA's.</li> </ul>	268		
Propulsion	<ul style="list-style-type: none"> <li>o Ascent Propulsion Subsystem</li> </ul>	468		
Reaction Control	<ul style="list-style-type: none"> <li>o Fuel, Oxidizer &amp; He Tanks (1/2 ship set)</li> </ul>	82	<ul style="list-style-type: none"> <li>o Vent. Valves</li> </ul>	15
Communications	<ul style="list-style-type: none"> <li>o Erectable S-Band Antenna</li> </ul>	14	<ul style="list-style-type: none"> <li>o Antenna Switching Matrix</li> </ul>	10
Controls and Displays	<ul style="list-style-type: none"> <li>o S&amp;C and Prop. Controls</li> </ul>	20		
	<div>RECEIVED</div>			

# ATTACHMENT II (Continued)

SUBSYSTEM/COMPONENT	REMOVED (POUNDS)	ADDED (POUNDS)
Explosive Devices		<ul style="list-style-type: none"> <li>o Payload Deployment Mechanisms</li> </ul>
Government Furnished Equipment	<ul style="list-style-type: none"> <li>o Science Equipment (A/S)</li> <li>o Science Equipment (D/S)</li> <li>o Crew Provisions</li> <li>o TV Camera</li> <li>o PLSS Batteries and LiOH (D/S)</li> </ul>	<ul style="list-style-type: none"> <li>o Payload</li> </ul>
Liquids and Gases	<ul style="list-style-type: none"> <li>o Ascent Water</li> <li>o Descent Stage GOX</li> <li>o Ascent Stage GOX</li> <li>o Lunar Stay Water</li> <li>o A/S Prop He</li> </ul>	
Propellant (Non ΔV)	<ul style="list-style-type: none"> <li>o Ascent Stage Unusable</li> <li>o RCS Unusable (1/2)</li> <li>o RCS Attitude (Ascent)</li> </ul>	
Propellant	<ul style="list-style-type: none"> <li>o Ascent Propellant</li> <li>o RCS ΔV (Ascent)</li> </ul>	
TOTALS	Removed Components	Added Components

## LEC Software Changes

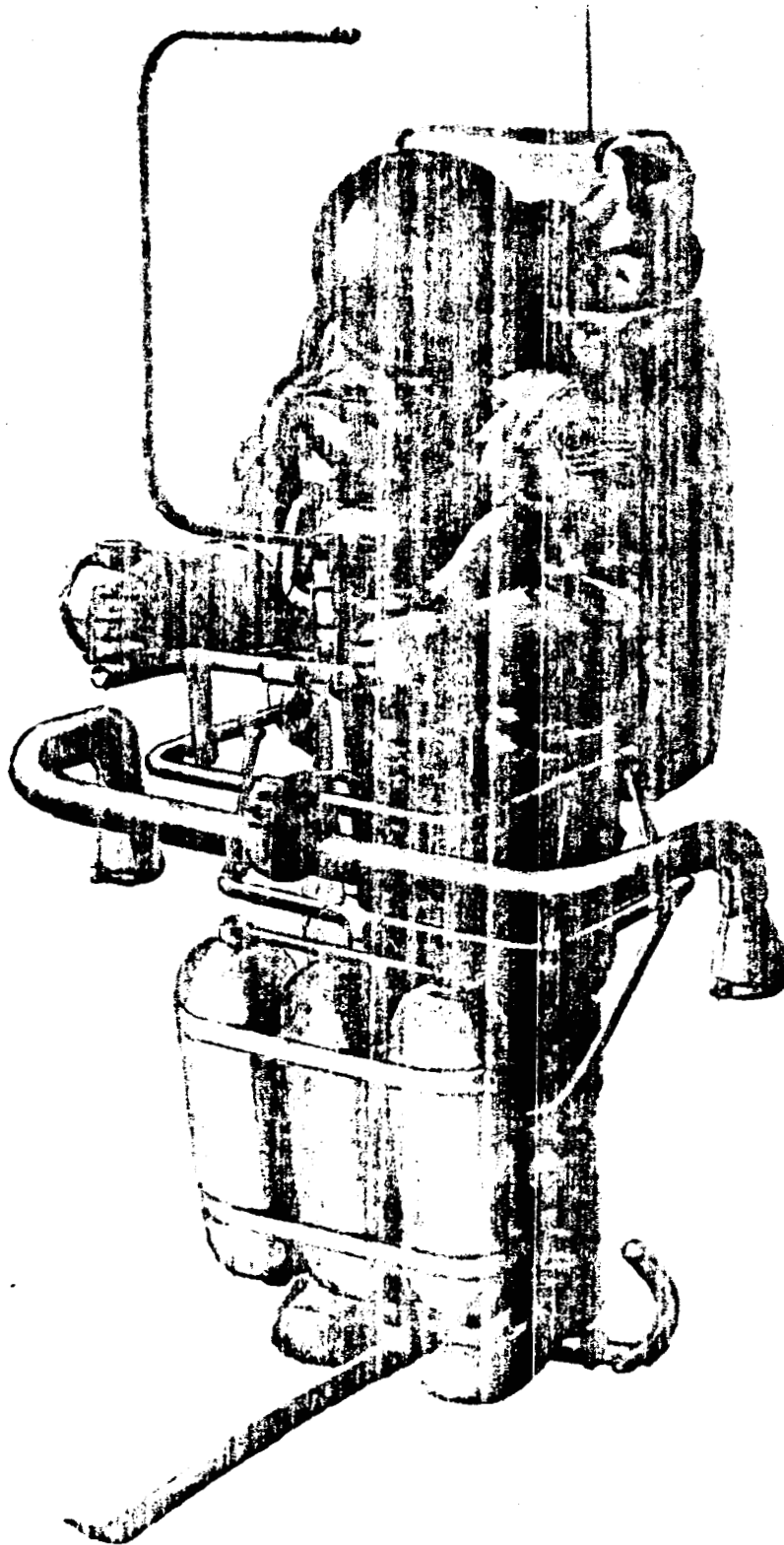
Delete: Abort, Ascent and Rendezvous Routines  
 Modify: Control and Landing Phase Routines  
 Add: Star Location, Fine Alignment and IM Mission Programmer Routines

PRELIMINARY



**BELL AEROSYSTEMS**

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BELL AEROSYSTEMS A **Textron** COMPANY

FIGURE I

**BELLCOMM, INC.**

Subject: MSFC Lunar Mobility Task Team      From: J. C. Slaybaugh  
Meeting, September 3, 1969 -  
Case 320

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